AN EXAMINATION OF PERFORMANCES ON FACIAL RECOGNITION, EMOTIONAL RECOGNITION, AND VISUOSPATIAL TASKS ACROSS INDIVIDUALS WITH AUTISM SPECTRUM CONDITION, UNAFFECTED SIBLINGS, AND TYPICALLY DEVELOPING INDIVIDUALS

A Thesis

Presented to the Faculty of Human Ecology

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of

Master of Arts

by

Darshana Kamal Tuladhar

August 2014

ABSTRACT

Autism spectrum condition (ASC) is a prevalent developmental disorder which is characterized as having repetitive behavior and deficits in both communication and social skills. There is evidence that first degree relatives such as unaffected siblings of individuals with ASC share some of these traits too. Within ASC literature there is conflicting results concerning whether individuals with ASC and unaffected siblings perform poorly on tasks that require facial and emotional recognition and whether these individuals are able to perform visuospatial tasks significantly better than typically developing individuals. The purpose of our study is to determine whether individuals with ASC and unaffected siblings have similar performances on tasks such as the Benton Facial Recognition Test (BFRT), Reading the Mind and the Eyes Test (RMET), Weschler Abbreviated Scale of Intelligence, second edition (WASI-II), and Embedded Figures test (EFT) which test facial recognition, emotional recognition, IQ, and visuospatial manipulation respectively. In addition we wanted to examine whether there were any patterns on task performances that are associated with individuals with ASC, unaffected siblings, and typically developing individuals. We found that individuals with ASC perform significantly worse than typically developing individuals on the BFRT. In addition we found that unaffected siblings outperformed individuals with ASC on both verbal IQ and full IQ of the WASI-II. We found no clear relationships between group and task performance.

BIOGRAPHICAL SKETCH

Growing up, I was always curious about the human brain, behavior and how it worked. I put my curiosity to good use as an undergraduate researcher at the University of Rochester where I examined the effects of word frequency and response time. Since earning my Bachelors in Science in Brain and Cognitive Science, my research in the field of cognitive psychology has been diverse, ranging from sleep research to my research concerning individuals with autism and individuals with Parkinson's disease. My interest in clinical populations started here at Cornell University in the Laboratory for the Neuroscience of Autism. It is here where I explored cognitive differences in children with autism spectrum disorder (ASD). While working with Dr. Matthew Belmonte, I tested theories such as Weak Central Coherence and Theory of Mind in individuals with autism. Following my time at Cornell I became graduate student and earned a Masters in Science in cognitive psychology at the University of Pittsburgh. I worked with Dr. Julie Fiez investigating memory and learning. Specifically, I examined the role of the basal ganglia and hippocampus in implicit and explicit memory.

It is through working at different laboratories that I am able to clearly see that I would like my career to move towards exclusively researching clinical populations. Ultimately, I would like to contribute to the overall knowledge within these special populations through research.

My awards include being a recipient of the Ezra H. Hale Scholarship (2006-2007) at the University of Rochester. In 2010 I was a recipient of the National Science Foundation Graduate Research Fellowship.

I dedicate this thesis to my parents Arun and Shakun Tuladhar, who have supported me throughout my journey(s) in graduate school.

ACKNOWLEDGMENTS

First and foremost I would like to thank my parents Arun and Shakun Tuladhar who have supported and continue to support me throughout my life by always pushing me to be my best. I thank my best friend and sister Mahima for her endless entertaining phone calls and instant messages throughout this process. I thank Matthew Belmonte for taking me in as a student at Cornell in the last hour and believing in my capabilities even when I did not. His support ultimately led to me writing a successful National Science Foundation proposal and a new found confidence. I am grateful to have had him as a mentor throughout my graduate school years at both Cornell and Pittsburgh and happy to say that he still mentors me to this day (and hopefully will continue to mentor me.) Finally, I thank Suman Giri for his endless support throughout my graduate and post graduate years.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

Autism Spectrum Condition

Autism spectrum condition (ASC) is a complex, pervasive developmental disorder that affects 1/68 births in the United States (Baio, 2014.) Three distinct behavioral traits often used to define ASC include repetitive behaviors and impairments in both social interactions, and communication. In addition, differences in genetic, cognitive, and behavioral phenotypes have been associated within individuals with ASC (Gerdts & Bernier, 2011.) Simon Baron-Cohen has supported that when examining cognitive and behavioral differences deeper, individuals with ASC have particular trouble with emotional understanding, recognizing other individual's mental states, and facial recognition (Baron-Cohen, 1997). On the other hand, there are some traits where individuals with ASC excel. Minshew & Goldstein (1997) found that individuals with ASC are able to perform significantly better than typically developing individuals on figure disembeddment tasks, suggesting a superior ability to manipulate spatial areas. There is evidence suggesting that these behavioral traits may be shared by first degree relatives such as siblings of individuals with ASC who do not have a diagnosis of the disorder (Yirmiya ,Gamliel, Pilowsky, Feldman, Baron-Cohen, & Sigman, 2006; Dalton, Nacewicz, Alexander, & Davidson, 2007; Toth, Dawson, Meltzoff, Greenson, & Fein, 2007; Zwaigenbaum, Bryson, Rogers, Roberts, Brian, and Szatmari, 2005; Stone, McMahon, Yoder, & Walden, 2007.) This thesis attempts to reveal if this is in case the fact by: 1. reviewing tasks individuals with ASC have difficulty with , 2. reviewing tasks individuals with ASC excel on, 3. reviewing tasks and traits that unaffected siblings share with their sibling with autism, 4. contradicting evidence concerning the shared traits and finally 5. the motivation of our study.

Tasks that are difficult to perform for individuals with ASC

There is evidence that individuals with ASC have a difficult time processing and recognizing emotions when conveyed on an individual's face which we will call facial affect (Kirchner, Hatri, Heekeren, & Dziobek, 2010; Kuusikko, Haapsamo, Jansson-Verkasalo, Hurtig, Mattila, & Ebeling, 2010; & Smith, Montagne, Perrett, Gill, & Gallagher, 2010.) A complex facial affect task found that individuals with autism performed worse than typically developing individuals (Smith et. al, 2010.) Smith and colleagues (2010) examined individuals with high functioning autism (HFA) on the Emotion Recognition Task which consisted of stimuli that blended multiple emotions conveying complex, mixed emotions. The stimuli were constructed by varying the intensity (via percentage) of two emotions in one face. They found that the group with ASC was less accurate than the control group and the performance decreased significantly when recognizing the emotions of anger and surprise (Smith et al., 2010). One may argue that perhaps this task is too difficult for individuals with ASC and that perhaps if the task was less complex, for instance conveying one emotion, individuals with ASC may be able to perform better.

A facial affect task which conveyed only a singular emotion found that individuals with ASC younger than 12 were able to perform the task but adolescent individuals with ASC were unable to suggesting that age may play a contributing factor when processing facial affect (Kuusiko et al., 2009.) The study found that there were no significant differences in performance on a facial affect task between children with ASC and typically developing individuals if both groups were younger than 12. However, when examining individuals with ASC older than 12 on the same facial affect task it was observed that they performed significantly worse compared to their typically developing counterparts (Kuusiko et al., 2009.) These findings suggest that there is a shift in the ability to recognize emotions, where individuals with ASC that are older than 12 experience a significant decline in emotional recognition accuracy.

Two other abilities that are impaired within individuals with ASC are the abilities to recognize emotion conveyed through the eyes and recognizing faces (Kirchner et al., 2010, Scherf, Behrmann, Minshew, & Luna, 2008.) One task that is able to test the ability to recognize emotion through the eyes is the Reading the Mind and the Eyes Test (RMET) (Simon-Baron-Cohen, 2001.) Kirchner and colleagues (2010) administered the RMET and the Cambridge Face Memory Test (CFMT), which examines the ability to recognize faces, to individuals with ASC and matched controls. The study found that individuals with ASC performed worse on both the RMET and CFMT. Furthermore, Scherf et al. 2008 found that when faces were either presented upright or inverted (upside down) that individuals with ASC performed worse than typically developing individuals. In another investigation led by Wolf, Tanaka, Klaiman, Cockburn, Herlihy, Brown, McPartland, Kaiser, Philips, & Schultz (2008) implemented The Let's Face it! battery which consisted of testing different aspects of facial recognition such as matching identity by expression, matching identity across masked featured test, and a simple facial recognition. Individuals with ASC performed significantly worse than typically developing participants on the battery (Wolf et al., 2008.)

So why is it that individual's with ASC have a difficult time with facial and emotional recognition? In addition to examining the RMET and CFMT Kirchner's investigation also employed an eye tracker to examine eye gaze patterns and performance on the two tasks. The eye tracker found that compared to the control group, individuals with ASC spent less time looking at the eyes of the stimuli within the tasks (Kirchner, 2010). Kirchner suggested that perhaps this lack of focus of gazing in the stimuli's eyes within the group with ASC may be the cause in differences in performance.

The differences in facial recognition performance is not just limited to the behavioral domain but also can be expanded into neurophysiological domain which may offer some explanation to the observed behavioral differences (Webb, Dawson, Bernier, & Panagiotides, 2006.) In an event related potential (ERP) study examining facial processing Webb found differences existed at a very young age. Young toddlers who were diagnosed with ASC and typically developing toddlers were found to have differences in latency and localization depending on whether the visual stimulus was a face or an object. When looking at faces, the typically developing group had a more right lateralized response compared to the bilateral response of the ASC group. The study also found that toddlers with ASC responded faster physiologically to objects more than typically developing individuals and also responded slower to faces compared to the typically developing individuals. Webb's study revealed that the differences do not only exist on a behavioral level but at a neurophysiological level within individuals with ASC. Through this study Webb reveals there may be a fundamental difference on how individuals with ASC respond to objects versus faces.

Tasks that are less difficult to perform for individuals with ASC

There is a significant amount of evidence supporting that individuals with ASC have trouble performing facial and emotional recognition tasks however there are studies that support a domain of tasks which individuals with ASC excel on which is figure disembbedment (Minshew & Goldstein, 1997; Happe & Frith, 2006; Malisza, Clancy, Shiloff, Foreman, Holden, & Jones, 2010.) Individuals with ASC are able to parse independent components from a larger shape made of multiple components that contain target shapes significantly faster than a typically developing population (Happe & Frith, 2006). Further support of this ability was illustrated by by Malisza and colleagues (2010) where an fMRI study was conducted. They found that a group with ASC was slightly quicker on average then a typically developing control group when performing a figure disembeddment task, the Hidden Figures Test. Malisza also found that typically developing controls had more brain activation on average than ASC individuals when performing the task indicating perhaps it took more cognitive resources to perform the task for typically developing individuals (Malisza et al., 2010).

In sum, individuals with ASC perform worse on tasks that require recognizing faces and emotions but excel on tasks that require spatial manipulation. The tasks focusing on faces and emotions illustrate how individuals with autism have difficulties within the social domain. However they are not the only individuals that have difficulties performing tasks that tap into the social and language domains. There is evidence that these specific traits are shared with first degree relatives such as parents and unaffected siblings of individuals with autism.

Shared traits of unaffected siblings

Differences in social interactions can be detected within unaffected siblings (SIB) as early as 4 months (Yirmiya, Gamliel, Pilowsky, Feldman, Baron-Cohen, & Sigman , 2006.) At 4 months of age, social interactions were measured using a paradigm known as mother infant synchrony during free play. Synchrony is the metric for measurement which is based upon how appropriately infants interact with their mother during free play. There are established play behavior that researchers look for such as averting, attending to an object, socially attending, object play, and social play. Yirmiya and colleagues found that unaffected siblings were less synchronous than siblings of typically developing counterparts. These results suggest that SIB individuals have differences in social interactions starting at an early age. Further evidence supporting differences in the social domain was illustrated by the still face paradigm. Yirmiya and colleagues (2006) revealed that SIB individuals were able to go longer without being upset during an episode where mothers did not interact with their infant; whereas siblings of typically developing individuals were more likely to become upset sooner.

Individuals with autism and unaffected siblings were both found to have different eye gaze patterns when looking at faces (Dalton et al., 2007.) Individuals with autism, unaffected siblings, and typically developing individuals performed a facial recognition task where they were asked to identify a photo of a face as either familiar or unfamiliar. Familiar photos were composed of family members and friends of the participants where unfamiliar photos were people who they did not know. Individuals with autism performed significantly worse than both unaffected siblings and typically developing individuals. Dalton and colleagues also examined eye gaze and found that individuals with autism spend a significant less amount of time looking at the eyes and mouth whereas typically developing individuals spent a significant portion of time looking at eyes. Interestingly siblings also spent significantly less time looking at the eyes however they focused on the mouth of the face. This suggests that perhaps unaffected siblings have aberrant visual gaze when looking at faces which may cause impairments in social interactions.

Studies have illustrated that at a young age siblings of individuals with ASC have differences in both social interactions and communication than typically developing individuals (Toth et al., 2007; Zwaigenbaum et al., 2005; Stone et al., 2007.) It appears that these differences last throughout adulthood as unaffected adult siblings share personality traits with their siblings with autism which include being aloof, shy, undemonstrative, impulsive, sensitive, self-conscious, and eccentric (Murphy, Bolton, Pickles, Fombonne, Piven, & Rutter, 2000.)

In Yirmiya and colleagues (2006) thorough study of social and language development, they found that unaffected siblings of individuals with autism had differences in language development compared to siblings of typically developing individuals. At 14 months of age both groups performed the Bayley Scales of Infant Development (BSID III). A significant difference was found within the language score toward the direction of unaffected siblings of autism having a lower developmental age than their age of 14 months. A larger group of toddlers were found to have lower language age within unaffected siblings with autism than siblings of typically developing individuals. The Checklist for Autism in Toddlers (CHAT) was also employed where unaffected siblings of individuals with autism were found to have a higher score than siblings of typically developing individuals. Yirmiya and colleagues study supported the theory that although unaffected siblings of individuals with autism did not share a clinical diagnosis they shared other traits as their diagnosed siblings within the realm of language and social cognition.

Contradicting Evidence

Although studies have illustrated that individuals with autism and unaffected siblings share personality traits, impairments in language, and social aspects there are studies that contradict these findings. Szatmari, Jones, Tuff, Bartolucci, Fisman, & Mahoney (1993) employed the Vineland Adaptive Behavior Scales (VABS), which is used to diagnose developmental disorders such as autism, and found that there were no differences between unaffected siblings and typically developing individuals in communication and social aspects. Furthermore there is contradicting evidence within the realm of tasks testing emotional understanding which is associated with the concept of Simon Baron-Cohen's Theory of Mind (ToM.) For instance unaffected siblings were found to perform worse than typically developing individuals when asked to determine the emotion from the RMET however, other studies have found that unaffected siblings are able to perform other tasks rooted in ToM without any problem (Dorris, Espie, Knott, & Salt, 2004; Szatmari et al., 1993; Ozonoff, Rogers, Farnham, & Pennington, 1993; Shaked, Gamliel, & Yirmiya, 2006.)

There exists a vast amount of literature examining similarities and differences between individuals with autism and their unaffected siblings. It is unclear whether these similarities and differences may actually exist between these two groups. The broader purpose of this thesis is to further investigate individuals with autism and unaffected siblings on performances examining emotional recognition, understanding others mental states, facial recognition, and spatial manipulation.

CHAPTER 2

MOTIVATION OF CURRENT INVESTIGATION

Motivation

Within the field of autism research, there have been many studies examining the different domains autism may affect. We are interested in examining the domains of facial recognition, social cognition, and visuospatial tasks. There are contradictions within the literature concerning the performances on these domains for individuals with autism and unaffected siblings (Dorris et al., 2004; Szatmari et al., 1993; Ozonoff et al., 1993; Shaked et al., 2006.) This thesis is an attempt to uncover whether if there are actual differences that exists between individuals with autism and unaffected siblings. The first aim of this study is to re-examine performances on facial recognition, the ability to recognize emotions, general IQ, and the ability to manipulate visuospatial tasks focusing on individuals with autism (ASC), unaffected siblings (SIB), and typically developing individuals (TYP.)

The second aim is to investigate whether if there is an underlying pattern that is associated with performances on these tasks testing the aforementioned domains within individuals with ASC, SIB, and TYP. An interesting pattern that appears to emerge from the literature is that individuals with ASC perform significantly worse on emotional recognition tasks but excel on tasks that involve visual spatial tasks (Kirchner et al., 2010; Kuusikko et al., 2010; Smith et al., 2010; Minshew & Goldstein, 1997; Happe & Frith, 2006; Malisza et al., 2010.) We would like to address this pattern by examining whether individuals with ASC have a specific pattern associated with their performance on a task. For example, if an individual with ASC tested well on a spatial task would that mean they perform worse on the social emotional recognition task? We will also extend this question out to SIB and TYP groups.

To examine performances on the domains of interest we implemented widely used psychometric tests such as the Weschler Abbreviated Scale of Intelligence (WASI-III) to attain Verbal IQ, Performance IQ, and Full IQ (Weschler, 2011.) In order to examine facial recognition capabilities the Benton Facial Recognition Test (BFRT) was used (Benton, Sivan, Hamsher, De, Varney & Spreen, 1983.) The Reading the Mind and Eyes Test (RMET) was used for emotion recognition (Baron-Cohen, 2001) and finally the Embedded Figures Task (EFT) for visuospatial tasks.

Predictions

Based on literature supporting that individuals with ASC have a difficult time with social cognition and emotional recognition we predict that individuals with ASC will perform significantly worse on the BFRT than SIB and TYP individuals. In addition we also predict that individuals with ASC perform significantly worse than SIB and TYP individuals on the RMET. Furthermore, we predict that unaffected siblings will perform better on both the BFRT and RMET than individuals with ASC but worse than TYP individuals. Finally, TYP individuals will outperform both individuals with ASC and unaffected siblings on both the facial recognition task and RMET.

There is mounting evidence that supports that individuals with ASC are significantly better at visual spatial tasks. We predict that individuals with ASC will perform significantly better than SIB and TYP individuals on the EFT and the performance aspect (which tests spatial abilities) of the WASI-II. Individuals with ASC will also be significantly faster in performing the EFT than SIB and TYP individuals. As for SIB individuals, the literature is not as clear as to whether they are able to have superior performances on these tasks; however based on the literature we believe that SIB individuals share the ability to manipulate spatial tasks with their affected siblings. Therefore we predict that SIB individuals will have a higher Performance IQ than TYP individuals but will not perform as well as their affected siblings. As far as the EFT we predict that SIB individuals will outperform TYP individuals in both accuracy and time to complete the task however they will not perform as well and be slower than individuals with ASC. Typically developing individuals will perform significantly worse than both individuals with ASC and SIB on the Performance IQ and perform significantly worse than both groups on the EFT.

Finally, we predict that individuals with ASC will not perform as well as SIB and TYP individuals on Verbal IQ of the WASI. However, SIB and TYP individuals will both outperform individuals with ASC on Verbal IQ of the WASI.

CHAPTER 3

METHODS

Participants

Participants with Autism Spectrum Condition (ASC)

Participants (N = 18) who were diagnosed on the spectrum of autism included individuals with ASC and Asperger's Syndrome. We also recruited individuals with Pervasive Development Disorder non-specific (PDD-NOS.) Participants with ASC or diagnosed with PDD-NOS were excluded if they possessed any co-morbid genetic disorders such as Fragile X syndrome, neurofibramatosis, tuberous sclerosis, Rett syndrome, Angelman syndrome, Prader-Willi syndrome, and Smith-Lemli-Opitz syndrome. Diagnosis of autism was confirmed with the Autism Diagnostic Interview-Revised (ADI-R) by our principal investigator who is a certified rater (Lord et. Al, 1994.)

Unaffected Siblings (SIB)

Unaffected siblings (N=7) were recruited from our participant pool of individuals with ASC. A few families we worked with had a child with ASC and unaffected child who matched closely in age. Unaffected siblings had to have no diagnosis of autism and any other developmental disorder in addition to any genetic disorders.

Typically Developing Individuals (TYP)

A total of 16 typically developing participants were recruited with no history of ASC. Participants excluded individuals with any personal and family history of psychiatric or neurological disorders, traumatic brain injury, and any diagnosis of developmental disorders. All siblings and typically developing individuals were assessed for qualities resembling autism through the Broader Phenotype Autism Symptom Scale which was administered by a qualified rater (Dawson, Estes, Munson, Schellenberg, Bernier, and Abbot, 2006.)

All participants had to possess the ability to verbally communicate, comprehend oral instructions, and full use of their arms and hands in order to perform the experimental tasks. In addition, all participants had to be 10-15 years of age at the time of testing with no sensory deficits such as blindness, color blindness, or deafness which would interfere with testing.

Materials

Benton Facial Recognition Test

The Benton Facial Recognition Test (BFRT) is a widely used standardized tool to examine the ability to recognize human faces. The test is a forced choice task that consists of 22 items composed of images of faces. Each item consists of an image of a target face, which can be male or female, with six choices of images also composed of similar faces and target faces. Participants are instructed to find the target face from the choices given. The first six items only have one target face in the given choices. The remaining 16 items are associated with three target faces in the given choices. There are two versions of the tests that can be administered; this thesis used the long-form version.

Reading the Mind and the Eyes Test

The Reading the Mind and the Eyes Test (RMET) is a forced choice task used to measure the ability to recognize human emotions. The task is composed of 36 images of human eyes conveying a specific emotion. With each image there were four possible choices of emotions and participants were instructed to pick the best option (Baron-Cohen, 2001.)

A study performed by Vellante, Baron-Cohen, Melis, Marrone, Petretto, Masala, and Preti (2013) found a satisfactory score for the internal consistency of the RMET (Cronbach's alpha score was .605.) In addition, the test-retest reliability was found by a intraclass correlation coefficient, which was .833.

Embedded Figures Test

The Embedded Figures Test (EFT) is a force choice task that tests an ability to parse out component figures within more complex figures. Participants were given a target shape followed by two complex shapes, one composed of the given target choice. Participants were then instructed to pick the figure they thought the target shape was embedded. The task was administered through a laptop with a total of 12 figures. Individuals had up to 50 seconds to make a response, if they did not make a response the trial was coded as incorrect and would move to the trial. Each response was timed (Witkin, Oltman, Raskin, & Karp, 1971.)

Weschler Abbreviated Scale of Intelligence, Second Edition

The Weschler Abbreviated Scale of Intelligence – Second Edition (WASI-II) is a standardized, widely used tool to measure cognitive functioning. The WASI-II is composed of two components, the Verbal and Performance IQ, which are both composed of subtests. A Full Scale IQ can be determined by combining the Verbal and Performance IQ together.

The Verbal component is composed of two subtests, Vocabulary which asks participants to define words and Similarities which asks individuals to find the relationship between two given words. The Verbal subtests assess crystallized abilities. On the other hand, Performance IQ measures nonverbal fluid abilities and visuomotor and coordination skills with Matrix Reasoning and Block Design subtests respectively (Weschler, 2011.)

Broader Phenotype Autism Symptom Scale

The Broader Phenotype Autism Symptom Scale (BPASS) is a tool used to measure behavioral characteristics associated with autism within individuals who do not have a diagnosis of ASC but display some characteristics resembling autism (also known as the broader phenotype of autism.) Areas measured include social motivation, social expressiveness, conversational skills, and flexibility. The BPASS is composed of two sections: the first section is a semi-structure interview composed of seven questions that assesses parental responses to their own functioning or their child's functioning. The second section consists of six items based on observation between the parent and child. The internal consistency of the BPASS is good, the Cronbach's alpha for Social Motivation is .76, .91 for Expressivity, .89 for Conversational skills, and .60 for Flexibility/Range of Interests (Dawson et al., 2006.)

Autism Diagnostic Interview-Revised

The Autism Diagnostic Interview-Revised (ADI-R) is a semi-structured interview given to caregivers of children and adults that may have a possible diagnosis of ASC or PDD-NOS. This interview allows investigators to diagnose ASC with a built in algorithm based on the definition of autism by the World Health Organization and Diagnostic and Statistical Manual of Mental Disorders IV. The ADI-R is composed of five areas of life that are examined which include opening questions, communication, social development and play, repetitive and restrictive behaviors, and general behavior problems.

The internal consistency of the ADI-R was measured for each area of life. The Cronbach's alpha for social area is .95, for restricted and repetitive behaviors it is .69, for communication it is .84. These scores illustrate that the reliability of the ADI-R is good (Lord, Rutter, & Le Couteur, 1994.)

Procedure

All participants were recruited for a larger study through fliers to local school districts and autism support groups. All participants went through an initial phone screen which consisted of a quick interview that examined family and personal health history to ensure they qualified for our study. My thesis was part of a larger study which consisted of two phases. The first phase consisted of collecting psychometric data while the second phase was allotted for neuropsychological data collection located at the Laboratory for the Neuroscience of Autism at Cornell University. This particular thesis study concerns only the first phase of data collection. During the phone screen the initial phase of collecting psychometric data was scheduled at either our lab or the participant's home depending on which was more convenient for the family.

During the psychometric data collection phase participants performed a battery of tests which were administrated by a research assistant. These tests included the BFRT, RMET, WASI-II, and finally the EFT. When the family visited the laboratory, the ADI-R or BPASS was administered by a certified rater to the parents of the participant. If the child had ASC the ADI-R was implemented else the BPASS was used. All participants were compensated $50 dollars for their time. All procedures and methods were approved by the Institutional Research Board at Cornell University.

Statistical Analysis

All analyses were performed through the statistical package SPSS version 14.0 for PC. Variables were normally distributed however due to small sample sizes and unbalanced groups the Test of Homogeneity of Variances was implemented ($p < .05$).

To examine whether there were any differences in performances for facial recognition on the BFRT, RMET, WASI-II, and EFT between ASC, SIB, TYP groups an ANOVA test was performed. Specifically, these were one –way models with group (ASC, SIB, TYP) as a between subject factor and the task as a within subject measure. For all the tasks the ANOVAs examined mean accuracy or score for each task.. If group membership (ASC, SIB, TYP) affects performance, main effects of group, as well as an interaction would be expected. For example, individuals in ASC and SIB groups should excel of EFT and Performance IQ and should perform worse on BFRT and RMET compared to individuals in the TYP group. If the ANOVA yielded significant results a post hoc Tukey adjustment with a Bonferonni correction was implemented to ensure that the significant differences are indeed influenced by the task and not the sample size. In addition the post hoc test revealed which direction the significance was occurring.

To examine possible relationships and patterns on group membership and task (BFRT, RMET, EFT, WASI-II, and WASI-II sub-components (Verbal IQ and Performance IQ) Pearson's correlations were performed. Correlations were found significant both at the .01 and .05 level. All p-values are two tailed. Post hoc analysis was implemented using the Bonferonni test.

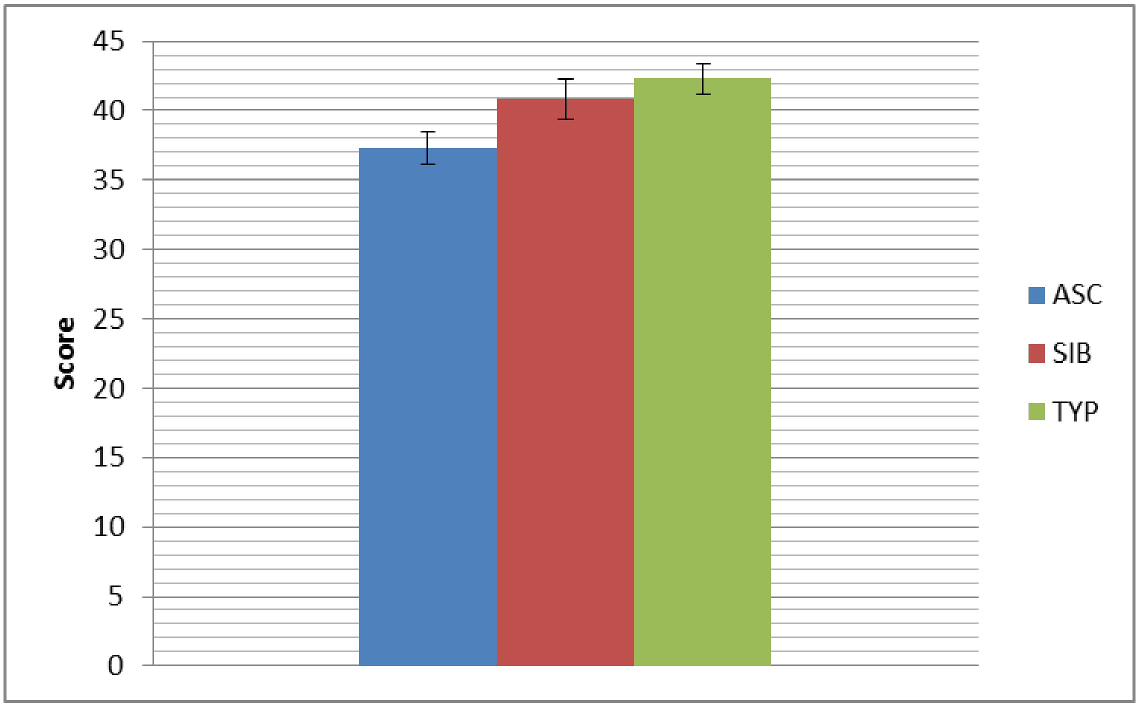
CHAPTER 4

RESULTS

The Benton Facial Recognition Test

For the BFRT a total of 18 individuals were in the ASC group, seven in the SIB group, and 16 in the TYP group. We examined performances for the three groups (ASC, SIB, TYP) on the BFRT with a one-way ANOVA on scores achieved. We found that the BFRT yielded significant differences $F(2, 38) = 4.708$, $p = 0.015$. To determine the direction of the differences in the ANOVA we implemented a post-hoc Tukey test with a Bonferonni correction. We found that there were no significant differences between the ASC group and SIB group on the BFRT. We also found that there were no significant differences in performance on the task between the SIB group and the TYP group. But the analysis reveals that there is a significant difference in performance between the ASC group and TYP, where the ASC group performed worse compared to the TYP group ($p = 0.014$.) This suggests that individuals with ASC are worse at recognizing faces than individuals in the SIB and TYP group (Figure 1.)

Figure 1. Performances of the ASC, SIB, and TYP groups on the Benton Facial Recognition Test



	N	Mean	Std. Deviation	Std. Error
ASC	18	37.33	4.923	1.160
SIB	7	40.86	3.891	1.471
TYP	16	42.13	4.617	1.154
Total	41	39.80	5.066	.791

Table 1. Performance Scores of Groups on Benton Facial Recognition Test

	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Bonferroni	ASC	SIB	-3.524	2.072	.292
		TYP	-4.792*	1.599	.014
	SIB	ASC	3.524	2.072	.292
		TYP	-1.268	2.108	1.000
	TYP	ASC	4.792*	1.599	.014
		SIB	1.268	2.108	1.000

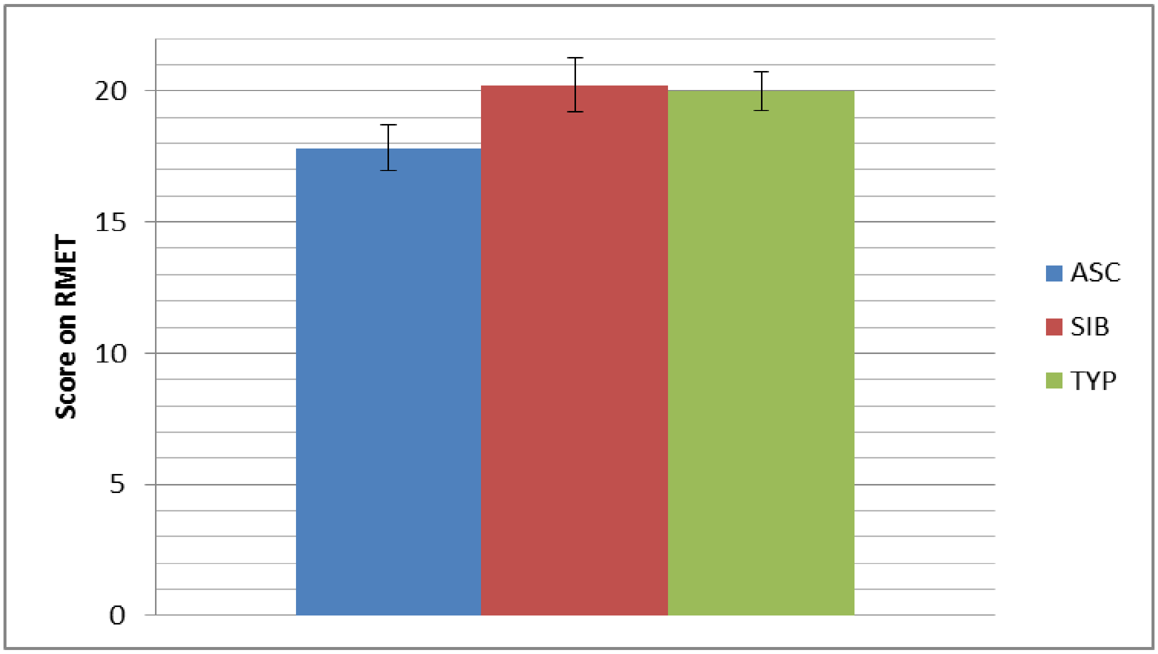
*. The mean difference is significant at the 0.05 level.

Table 2. Post-Hoc Bonferonni Analysis of Benton Facial Recognition Test

Reading the Mind and the Eyes Test

We performed a one-way ANOVA between the groups, ASC (n = 18), SIB (n = 9), and TYP (n=16) which found that there were no significant differences in performances on the RMET, F(2,40) = 2.381, p =0.105. These results support that there are no differences between individuals with ASC, SIB, and TYP when performing the RMET (Figure 2.)

Figure 2. Performances of the ASC, SIB, and TYP groups on the Reading the Mind and the Eyes Test



	N	Mean	Std. Deviation	Std. Error
ASC	18	17.83	3.730	.879
SIB	9	20.22	3.073	1.024
TYP	16	20.00	2.989	.747
Total	43	19.14	3.447	.526

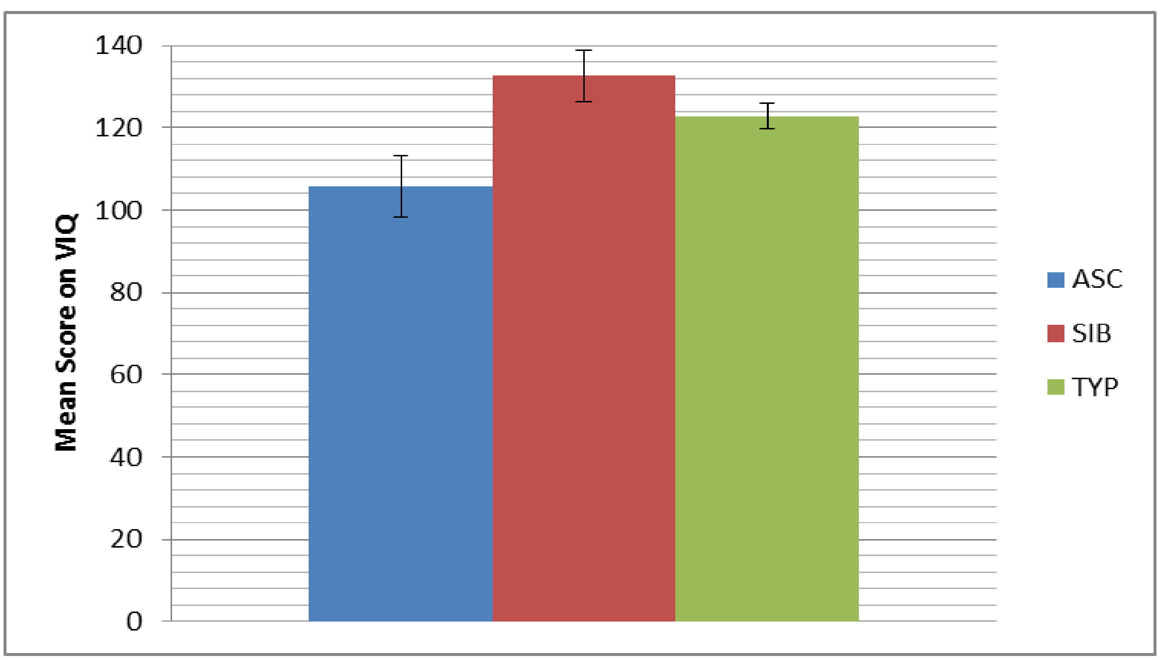
Table 3. Performance scores of the groups on the Reading the Mind and the Eyes Test.

Weschler Abbreviated Scale of Intelligence – Second Edition

Verbal IQ

A one-way ANOVA examining Verbal IQ score between groups (ASC , n = 18; SIB, n = 9; TYP, n = 16) found a significant difference in scores achieved, F (2,40) = 4.576, p = 0.016. Particularly the post-hoc Tukey test with a Bonferonni correction revealed that the SIB group score significantly higher on the verbal IQ then the ASC group however perform similarly to the TYP group. The means also show that that the SIB group has the highest score (mean = 132.67; SD = 18.722), followed by the TYP group (mean = 122.75; SD = 12.652), and the ASC group have the lowest group (mean = 105.67; SD = 31.417). These results suggest that individuals within the SIB group outperform their affected siblings (ASC) but perform similarly to individuals within the TYP group (Figure 3.)

Figure 3. Mean Performance Scores on Verbal IQ of the WASI - II for individuals in the ASC, SIB, and TYP group



	N	Mean	Std. Deviation	Std. Error
ASC	18	105.67	31.417	7.405
SIB	9	132.67	18.722	6.241
TYP	16	122.75	12.652	3.163
Total	43	117.67	25.362	3.868

Table 4: Mean Performance Scores on the VIQ for individuals in the ASC, SIB, and TYP Groups

	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Bonferroni	ASC	SIB	-27.000*	9.571	.022
		TYP	-17.083	8.055	.121
	SIB	ASC	27.000*	9.571	.022
		TYP	9.917	9.768	.948
	TYP	ASC	17.083	8.055	.121
		SIB	-9.917	9.768	.948

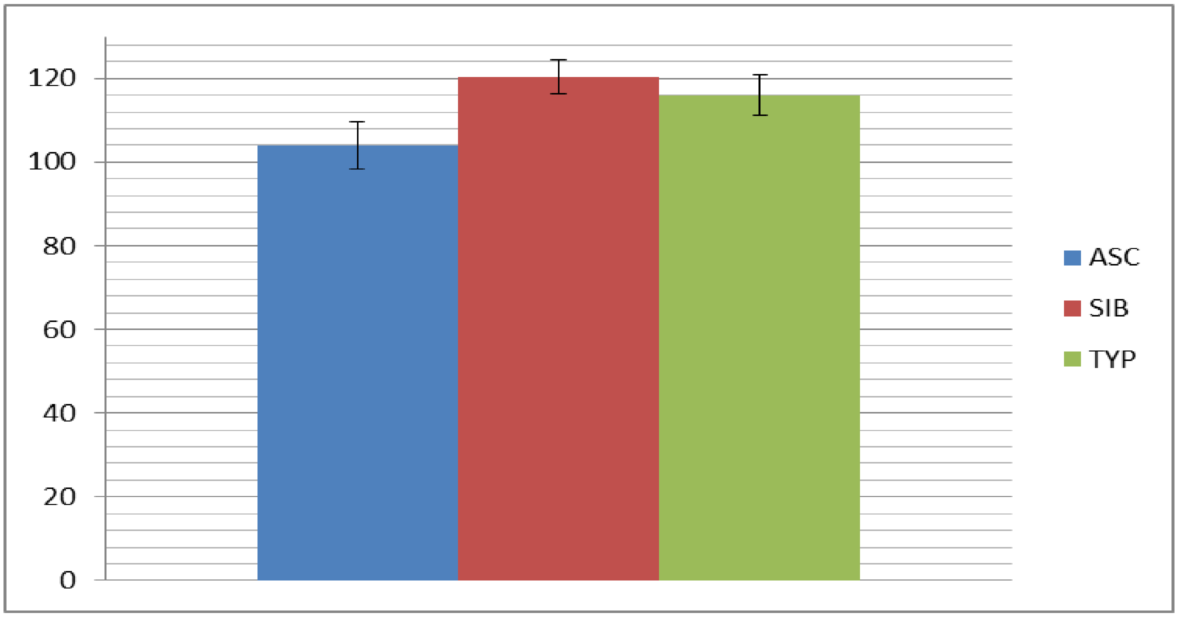
*. The mean difference is significant at the 0.05 level.

Table 5. Post-Hoc Tukey Test with Bonferonni Correction for Verbal IQ of the WASI-II

Performance IQ

A one-way ANOVA was performed to examine possible differences in scores on the Performance IQ. It appears by just looking at the means that the SIB group performs the best (n = 8; mean = 120.38; SD = 11.351), followed by the TYP group (n = 16; mean = 116.00; SD = 19.012), and surprisingly the ASC group performs the worst (n = 18; mean = 103. 94; SD = 23.856) However, the ANOVA reveals that there are no significant differences in performance IQ between the three groups. F(2,39) = 2.414 ; p =0.103.)

Figure 4. Mean Performance Scores on Performance IQ of the WASI - II for individuals in the ASC, SIB, and TYP group



	N	Mean	Std. Deviation	Std. Error
ASC	18	103.94	23.856	5.623
SIB	8	120.38	11.351	4.013
TYP	16	116.00	19.012	4.753
Total	42	111.67	20.941	3.231

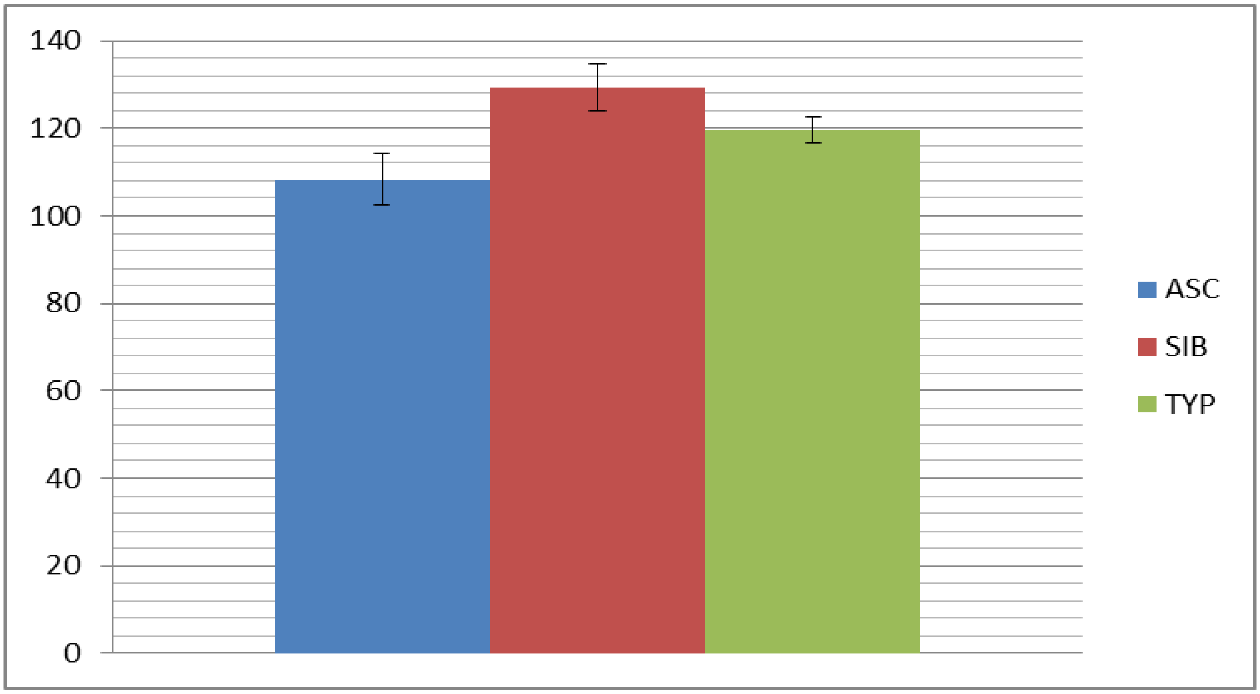
Table 6. Mean Performances Scores on the PIQ for individuals in the ASC, SIB, and TYP Groups.

Full IQ

After performing a one-way ANOVA the analysis illustrated that there are significant differences in Full IQ scores between the different groups (ASC, SIB, TYP), $F(2,40) = 3.693$; $p = 0.027$). The Tukey post-hoc test with Bonferonni correction reveals that the significant difference in IQ scores exists between the ASC and SIB group. Looking at the means the SIB group score the highest ($n = 9$; mean = 129.33; SD = 15.890) and the ASC the lowest ($n = 18$; mean = 108.28;

SD = 24.545). The TYP group lands in between with an average score of 119.69 (n = 16; SD = 2.986). However, since the groups are unbalanced we cannot clearly conclude that there are actual significant differences between the groups.

Figure 5. Mean Performance Scores on Full IQ of the WASI - II for individuals in the ASC, SIB, and TYP group



	N	Mean	Std. Deviation	Std. Error
ASC	18	108.28	24.545	5.785
SIB	9	129.33	15.890	5.297
TYP	16	119.69	11.943	2.986
Total	43	116.93	20.269	3.091

Table 7. Mean Performance Scores on Full IQ for individuals in the ASC, TYP, and SIB group.

	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Bonferroni	ASC	SIB	-21.056*	7.746	.029
		TYP	-11.410	6.519	.263
	SIB	ASC	21.056*	7.746	.029
		TYP	9.646	7.906	.689
	TYP	ASC	11.410	6.519	.263
		SIB	-9.646	7.906	.689

*. The mean difference is significant at the 0.05 level.

Table 8. Post Hoc Tukey Test on the Full IQ of the WASI-II

Embedded Figures Test: Accuracy

There are no significant differences between the groups in accuracy on the EFT task , F (2, 23) = 0.296; p = 0.747. Looking at the means the ASC group (n = 18; mean = 0.780; SD = 0.123) performs marginally better than the SIB group (n = 7; mean = 0.747; SD = 0.093) and TYP (n = 11; mean = 0.745; SD = 0.096).

	N	Mean	Std. Deviation	Std. Error
ASC	8	.779655	.1217537	.0430464
SIB	7	.747167	.0934619	.0353253
TYP	11	.744783	.0963296	.0290445
Total	26	.756155	.1010700	.0198214

Table 9. Mean Performances Scores on the EFT for individuals in the ASC, TYP, and SIB Group

Correlations between Psychometric Tests

We calculated Pearson's coefficients to find any correlations between the different psychometric tests we used in a pooled data set. The pooled data set consisted of all the groups in a combined mean for each significant test (BFRT, RMET, WASI-II, and EFT.) The test found significant correlation between the RMET and Benton ($n = 41$; $r = .584$; $p < 0.01$), Benton and Verbal IQ ($n = 41$; $r = .393$; $p < 0.05$); Benton and Performance IQ ($n = 41$; $r = .315$; $p < 0.05$), Performance IQ and Verbal IQ ($n = 43$; $r = .638$; $p < 0.01$), Performance IQ and Full IQ ($n = 43$; $r = .868$; $p < 0.01$), EFT accuracy and Performance IQ ($n = 21$; $r = .550$; $p < 0.01$), and between EFT accuracy and Full IQ ($n = 21$; $r = .535$, $p < 0.05$) (Table 11.) We wanted to take a closer look and examine the contribution of each group to the pooled results; we ran the test again but this time separated the data into the three diagnostic groups.

	Mean	Std. Deviation	N
RMET	19.14	3.447	43
Benton	39.80	5.066	41
Verbal IQ	117.67	25.362	43
Performance IQ	110.35	19.277	43
Full IQ	116.93	20.269	43
EFT accuracy	.7640909	.10280166	22
EFT latency	14.9195455	6.82876443	22

Table 10. Pooled means of all the participants for every Psychometric tests

		RMET	Benton	Verbal IQ	Performance IQ	Full IQ	EFT accuracy	EFT latency
RMET	Pearson Correlation	1	.584**	.235	.176	.258	-.077	-.240
	Sig. (2-tailed)		.000	.129	.258	.095	.740	.294
	N	43	41	43	43	43	21	21
Benton	Pearson Correlation	.584**	1	.393*	.267	.315*	-.298	-.157
	Sig. (2-tailed)	.000		.011	.091	.045	.215	.521
	N	41	41	41	41	41	19	19
Verbal IQ	Pearson Correlation	.235	.393*	1	.638**	.884**	.403	-.023
	Sig. (2-tailed)	.129	.011		.000	.000	.070	.923
	N	43	41	43	43	43	21	21
Performance IQ	Pearson Correlation	.176	.267	.638**	1	.868**	.550**	-.240
	Sig. (2-tailed)	.258	.091	.000		.000	.010	.295
	N	43	41	43	43	43	21	21
Full IQ	Pearson Correlation	.258	.315*	.884**	.868**	1	.535*	-.126
	Sig. (2-tailed)	.095	.045	.000	.000		.012	.587
	N	43	41	43	43	43	21	21
EFT accuracy	Pearson Correlation	-.077	-.298	.403	.550**	.535*	1	-.244
	Sig. (2-tailed)	.740	.215	.070	.010	.012		.275
	N	21	19	21	21	21	22	22
EFT latency	Pearson Correlation	-.240	-.157	-.023	-.240	-.126	-.244	1
	Sig. (2-tailed)	.294	.521	.923	.295	.587	.275	
	N	21	19	21	21	21	22	22

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 11. Pearson correlations for the different Psychometric tests within the pooled participant means.

Correlations between Individuals with ASC Performances & Psychometric Tests

There were significant correlations found among the psychometric tests within the ASC group (Table 12.) As expected there were significant correlation between the subtests of the WASI-II amongst each other, Verbal IQ and Performance IQ ($n = 18$; $r = .694$; $p < 0.01$), Verbal IQ and Full IQ ($n = 18$; $r = .875$; $p < 0.01$), Performance IQ and Full IQ ($n = 18$; $r = .882$; $p < 0.01$.) In addition, correlations were found between RMET and Benton ($n = 18$; $r = .557$; $p < 0.05$), Benton and Verbal IQ ($n = 18$; $r = .575$; $p < 0.05$), Benton and Performance IQ ($n = 18$; $r = .521$; $p < 0.05$), Benton and Full IQ ($n = 18$; $r = .563$; $p < 0.05$, EFT accuracy and Performance IQ ($n = 6$; $r = .816$. $p < 0.05$), and EFT accuracy and Full IQ ($n = 6$; $r = .893$; $p < 0.05$.)

		RMET	Benton	Verbal IQ	Performance IQ	Full IQ	EFT accuracy	EFT latency
RMET	Pearson Correlation	1	.557*	.334	.187	.401	-.450	.465
	Sig. (2-tailed)		.016	.176	.458	.099	.370	.353
	N	18	18	18	18	18	6	6
Benton	Pearson Correlation	.557*	1	.575*	.521*	.563*	-.143	-.045
	Sig. (2-tailed)	.016		.013	.027	.015	.786	.932
	N	18	18	18	18	18	6	6
Verbal IQ	Pearson Correlation	.334	.575*	1	.694**	.875**	.716	-.713
	Sig. (2-tailed)	.176	.013		.001	.000	.110	.112
	N	18	18	18	18	18	6	6
Performance IQ	Pearson Correlation	.187	.521*	.694**	1	.882**	.816*	-.659
	Sig. (2-tailed)	.458	.027	.001		.000	.048	.154
	N	18	18	18	18	18	6	6
Full IQ	Pearson Correlation	.401	.563*	.875**	.882**	1	.893*	-.831*
	Sig. (2-tailed)	.099	.015	.000	.000		.017	.040
	N	18	18	18	18	18	6	6
EFT accuracy	Pearson Correlation	-.450	-.143	.716	.816*	.893*	1	-.826*
	Sig. (2-tailed)	.370	.786	.110	.048	.017		.043
	N	6	6	6	6	6	6	6
EFT latency	Pearson Correlation	.465	-.045	-.713	-.659	-.831*	-.826*	1
	Sig. (2-tailed)	.353	.932	.112	.154	.040	.043	
	N	6	6	6	6	6	6	6

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 12. Pearson Coefficient for the Psychometric Tests within the ASC group.

Correlations between Unaffected Siblings' Performance & Psychometric Tests

Within the SIB group, the following tests had significant correlation with one another (Table 13) : RMET and Benton (n = 7; r = .807; $p < 0.05$), and not surprisingly Verbal IQ and Performance IQ (n = 9; r = .704; $p < 0.05$), Verbal IQ and Full IQ (n = 9; r = .960; $p < 0.01$), and Performance IQ and Full IQ (n = 9; r = .874; $p < 0.01$.)

		RMET	Benton	Verbal IQ	Performance IQ	Full IQ	EFT accuracy	EFT latency
RMET	Pearson Correlation	1	.806*	-.335	.021	-.224	.268	-.685
	Sig. (2-tailed)		.028	.378	.958	.562	.607	.133
	N	9	7	9	9	9	6	6
Benton	Pearson Correlation	.806*	1	-.627	-.390	-.611	-.932	-.458
	Sig. (2-tailed)	.028		.132	.388	.145	.068	.542
	N	7	7	7	7	7	4	4
Verbal IQ	Pearson Correlation	-.335	-.627	1	.704*	.960**	.360	.303
	Sig. (2-tailed)	.378	.132		.034	.000	.483	.559
	N	9	7	9	9	9	6	6
Performance IQ	Pearson Correlation	.021	-.390	.704*	1	.874**	.522	-.424
	Sig. (2-tailed)	.958	.388	.034		.002	.288	.403
	N	9	7	9	9	9	6	6
Full IQ	Pearson Correlation	-.224	-.611	.960**	.874**	1	.457	.058
	Sig. (2-tailed)	.562	.145	.000	.002		.363	.913
	N	9	7	9	9	9	6	6
EFT accuracy	Pearson Correlation	.268	-.932	.360	.522	.457	1	-.172
	Sig. (2-tailed)	.607	.068	.483	.288	.363		.744
	N	6	4	6	6	6	6	6
EFT latency	Pearson Correlation	-.685	-.458	.303	-.424	.058	-.172	1
	Sig. (2-tailed)	.133	.542	.559	.403	.913	.744	
	N	6	4	6	6	6	6	6

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 13. Pearson Coefficient for the Psychometric Tests within the SIB group

Correlations between Typical Developing Individuals' Performance & Psychometric Tests

In the typically developing group the analysis revealed two significant correlations which were found within the subtests of the WASI-II (Table 14): Verbal IQ with Full IQ ($n = 16$; $r = .690$; $p < 0.01$) and Performance IQ with Full IQ ($n = 16$; $r = .791$; $p < 0.01$). There were no other significant correlations found between the psychometric tests within the TYP group (Table 14.)

		RMET	Benton	Verbal IQ	Performance IQ	Full IQ	EFT accuracy	EFT latency
RMET	Pearson Correlation	1	.382	-.256	-.095	-.267	.244	-.364
	Sig. (2-tailed)		.145	.339	.727	.317	.526	.335
	N	16	16	16	16	16	9	9
Benton	Pearson Correlation	.382	1	-.055	-.305	-.277	-.015	.053
	Sig. (2-tailed)	.145		.839	.251	.298	.969	.892
	N	16	16	16	16	16	9	9
Verbal IQ	Pearson Correlation	-.256	-.055	1	.115	.690**	.185	.205
	Sig. (2-tailed)	.339	.839		.673	.003	.633	.596
	N	16	16	16	16	16	9	9
Performance IQ	Pearson Correlation	-.095	-.305	.115	1	.791**	.320	.045
	Sig. (2-tailed)	.727	.251	.673		.000	.401	.908
	N	16	16	16	16	16	9	9
Full IQ	Pearson Correlation	-.267	-.277	.690**	.791**	1	.280	.207
	Sig. (2-tailed)	.317	.298	.003	.000		.466	.592
	N	16	16	16	16	16	9	9
EFT accuracy	Pearson Correlation	.244	-.015	.185	.320	.280	1	-.102
	Sig. (2-tailed)	.526	.969	.633	.401	.466		.779
	N	9	9	9	9	9	10	10
EFT latency	Pearson Correlation	-.364	.053	.205	.045	.207	-.102	1
	Sig. (2-tailed)	.335	.892	.596	.908	.592	.779	
	N	9	9	9	9	9	10	10

**. Correlation is significant at the 0.01 level (2-tailed).

Table 14. Pearson Coefficient for the Psychometric Tests within the TYP group

CHAPTER 5

DISCUSSION

Do group differences exist within the performance of psychometric tests?

Our study examined if there were any differences or similarities between individuals with ASC, unaffected siblings, and typically developing counterparts within the domains of social-emotional cognition and visuospatial cognition by testing the ability to recognize faces and emotions, verbal capacity, spatial capacity, and the ability to visually manipulate complex shapes. We found significant differences in performances on some but not all the domains tested between individuals in the three groups.

The ability to recognize faces

We predicted that individuals with ASC would perform worse on the BFRT than individuals within the SIB or TYP group. Analysis of the BFRT supported one aspect of our prediction; we found significant results with a main effect of group where individuals in the ASC group perform significantly worse than individuals in the TYP group but no different than individuals within the SIB group. Further analysis reveals that individuals within the SIB did not perform significantly different from individuals in the TYP group. In fact, this study shows that the mean for the SIB group is slightly better than the ASC group but worse than the TYP. These results are interesting as they support the argument that individuals with ASC are worse at recognizing faces than their unaffected siblings and neuro-typical population. In addition, it supports that unaffected siblings are not as good as typically developing individuals but better than individuals with ASC.

Frith's Weak Central Coherence Theory may provide an explanation for the ASC group results on the BFRT. Frith's theory postulates that individuals with ASC are only able to focus on specific details (local) and are unable to understand the whole picture (global) therefore a task such as the BFRT may be difficult since it requires individuals to integrate multiple facial features such as the eyes, nose, mouth, and face shape in order to recognize the correct face(s) (Happe & Frithe, 2006.)

A possible reason for why unaffected siblings are not as good at recognizing faces as typically developing individuals is that they may possess a broader phenotype of autism. Individuals who do not have a diagnosis of autism but have characteristics that closely relate to ASC are proposed to display the broader phenotype. These characteristics include social cognition impairments which extend to facial and emotional recognition, communication, and repetitive behavior (Gerdts & Bernier, 2011.) Generally individuals with this phenotype are first degree relatives of individuals who have autism (Gerdts & Bernier, 2011.) It may be the case that because unaffected siblings have the broader phenotype it disrupts their ability to process faces with accuracy but not to the extent as individuals with ASC therefore they perform slightly better than their siblings with ASC but slightly worse than typically developing individuals.

Verbal capacity

Significant differences were found between the groups for the Verbal IQ score of the WASI-II. Individuals in the SIB group were found to have the highest score on the Verbal IQ that were significantly greater than the ASC and TYP group. There were no significant differences between individuals with ASC and TYP group. In addition, individuals in the ASC group earned the lowest score, and the TYP had a median score in between the ASC and TYP group. These results partially support our hypothesis that individuals with ASC perform the worst on the task but only significantly worse than the SIB group.

It is interesting that our SIB group significantly outperformed both the ASC and TYP group but it is important to remember that our sample population is very small for the SIB group (n = 9.) It is hard to draw conclusions concerning if the SIB group did indeed significantly outperform the individuals in the ASC and TYP group due to lack of power (Cohen, 1977.)

The ability to recognize emotions

We predicted that individuals in the ASC group would perform significantly worse than individuals in the SIB and TYP group on the RMET. However, our results yield that all three groups perform no different from one another. This was surprising since it contradicts with past research studies that have supported that individuals with ASC perform worse on social domains than typically developing (Kirchner et. al., 2010; Kuusikko et al., 2010; Scherf et al., 2008; Smith et al., 2010,& Wolf et al., 2008.) It may be possible that individuals with ASC are not impaired when recognizing emotions especially when given a task where the context is just limited to looking at eyes and no other facial features are incorporated such as the stimuli in the RMET. Again Frith's theory could be driving these differences in performances. For instance in a real world situation there are many other factors that play a role in the ability to recognize emotions such as context and body language. The ability to integrate these multiple input channels may be difficult for individuals with ASC thus making emotional recognition challenging however because the RMET is only examining a single input (the eyes) individuals with ASC may be able to perform the task.

A couple of more likely explanations to why our results did not reproduce past results is that our sample population is both very small for the SIB group and we tested a very specific population of individuals with ASC. In our study there are only nine individuals in the SIB group who took the RMET. Having such a small sample size makes it difficult to draw conclusions about the group or the task under examination because statistical power is not sufficient (Cohen, 1977.) In addition, our sample population is very specific. All but a few of our individuals in the ASC group are high functioning individuals who are integrated into society. In other words, they are enrolled in public school and included in regular classrooms therefore it is possible that these individuals are able to recognize emotions due to coping mechanisms they have developed over the years.

Full IQ

Our results illustrate that unaffected siblings score highest on the WASI-II and significantly better than the ASC group. It is likely that the verbal score of the SIB group is driving up their overall IQ score since there are no significant differences between the three groups on the performance aspect of the WASI-II. We must also take into account that the groups are unbalanced, the SIB group has only nine individuals, and therefore we cannot conclude that there are actual significant differences between the groups.

Visuospatial capabilities

We predicted that individuals with ASC would outperform individuals in the SIB and individuals in the TYP group on both the Performance IQ score of the WASI-II and the EFT. However our results found that there were no differences in scores on the performances of both these task scores. Once again we anticipated individuals with ASC and perhaps unaffected siblings to excel on these tasks due to past research supporting these claims (Minshew & Goldstein, 1997; Happe & Frith, 2006; Malisza et al., 2010.) It is possible that individuals with ASC are no different than unaffected siblings or typically developing individuals when performing these tasks. But once again it is important that we consider our sample size and population especially for the EFT. Only eight individuals with ASC, seven unaffected siblings, and eleven typically developing individuals participated in the EFT task; thus making it difficult to make clear interpretations based on our results.

Do specific patterns exist within each group?

We also wanted to explore whether there were performance patterns associated among the different psychometric tests used in this study hence Pearson correlation coefficients were performed. When examining Pearson's coefficients in the pooled data there initially appear to be many correlations occurring among the different psychometric tests. For instance there are significant correlations between the RMET and Benton, Benton with Verbal IQ of the WASI-II, Benton and the Performance IQ of the WASI-II, EFT accuracy with the Full WASI-II IQ, EFT accuracy with Performance IQ, and not surprising a strong correlation between Performance IQ with Verbal IQ of the WASI-II. By merely looking at these correlations one can assume that if you score well on the RMET you will score well on the BFRT and if there is a high score on Benton there will be a high score for Verbal IQ. However, just examining the pooled data does not provide a complete understanding of the underlying pattern that may exist. In order to have a deeper understanding of the performance pattern within each group we performed separate Pearson correlations for the ASC, SIB, and TYP group, where different patterns emerge.

The individual group analysis reveals that the ASC group is driving correlations to be significant in the pooled data for tests between the BFRT and Verbal IQ, BFRT and Performance IQ, EFT accuracy and Performance IQ, and EFT accuracy and Full IQ. The BFRT and Performance IQ may be related due to how ASC individuals visually process objects, which include both faces and shapes. It is believed with the Weak Central Coherence theory that individuals with ASC focus on individual features such as the eyes, mouth, nose, ears, hair, face shape, etc. (Happe and Frith, 2006.) This same technique may also be used when processing individual shapes in a complex figure or the ability to focus on individual shapes and patterns in the block building task such as in the WASI-II; therefore it is conceivable that there exists a significant correlated relationship in performance on the BFRT and Performance IQ. It is not surprising that there is a significant correlation between EFT accuracy and Performance IQ since both tests examine the ability to understand spatial relationships and patterns.

A few correlations among the tests and subtest are consistently significant in all three groups. As expected these correlations include Verbal IQ with Full IQ and Performance IQ with Full IQ. The sample population illustrates that all three groups perform fairly well on both the verbal and spatial component of the WASI. The Full IQ is based on the scores of the Performance IQ and Verbal IQ so naturally these scores will have a fairly strong relationship with one another.

Both ASC and SIB group performances result in significant correlations between the RMET and the BFRT. Both these tests use faces where they are testing a fundamental ability of possessing an understanding of social cues and social cognition. One possible explanation for this correlation is that these tasks involve facial features, one dealing with eyes and the other whole faces, which fall under the umbrella domain of social cognition. Therefore it is possible that if one has decent social cognition skills they would perform well on both the BFRT and RMET. Furthermore it may be the case that both SIB and ASC group are equipped with similar cognitive processing such as Frith's Weak Central Coherence Theory. It is possible that that both groups may be analyzing the stimuli down to the feature level rather than an integrative, whole level when trying to determine the correct answer. Therefore if an individual does possess Weak Central Coherence they would perform very well both on the BFRT and RMET. It is important to note that we should consider other factors when interpreting the results of this investigation such as characteristics of our sample population in addition to our sample population size.

Points of consideration

As noted earlier our sample size should be taken into account when interpreting the statistical analysis that produced our results. It was especially difficult to recruit individuals in the SIB group which led to a small number of participants in that particular group. For instance, only seven individuals in the SIB group took the BFRT and nine individuals for the RMET. The WASI-II was slightly more complicated; the Verbal IQ had a total of nine participants, whereas the Performance and Full IQ had only eight participants. The SIB group was not the only group with a small number of participants, for the EFT all the groups were lacking in numbers, ASC (n = 8), SIB (n = 7), and TYP (n = 11.) It is difficult to draw conclusions about the SIB group or draw valid comparisons between any of the two groups against the SIB due to lack of statistical power. As for the EFT it is hard to make any interpretations or explanations due to the minimal size of each sample population for each group.

The characteristics of our sample population may not be a real world representation of individuals with ASC, unaffected siblings, and typically developing individuals. Most of our participants with ASC, except for a few, were enrolled in a typical public school and consisted of individuals with High Functioning Autism, Asperger's Syndrome, or PDD-NOS. These characteristics of our individual's with ASC may have played a role in the outcome of our study. Perhaps individuals in our study were not as affected by the ASC therefore resulting in a few differences between the populations. It is also conceivable that our sample group with ASC, whom attending public school, have developed mechanism and strategies to be sufficient at social cognition and skills.

Finally, it is important to note that all of our participants were volunteers recruited from local support groups and schools. The individuals and families from these recruitment sources were willing to participate and highly motivated in order to help with understanding of ASC. This may have made them more motivated to perform well than our typically developing individuals.

CHAPTER 6

FUTURE INVESTIGATIONS

In order to strengthen our findings in future investigations it would be helpful to be more stringent when recruiting and creating groups when examining differences in performances on certain domains. As discussed, our group of individuals with ASC has a wide range of severity from low functioning autism, HFA, Asperger's Syndrome, and PDD-NOS which because of non-conformity may cause a difference in our results. We propose trying to achieve the most uniform group of individuals with ASC. For example, only recruit individuals with ASC who have Asperger's Syndrome or individuals with who have HFA. By having a uniform group it fathomable that clearer interpretations can be made concerning behavior and performances on tasks in question. In addition, having balanced groups would also make interpretations clearer about differences in performances due to having ASC, being an unaffected sibling, or a typically developing individual.

In future studies it may be interesting to examine social cognition that reflects a real world situation. The RMET is not representative of everyday interactions with people. Although eyes do convey a lot of social information, often body language and context must be discerned simultaneously to make an appropriate conclusion about an individual's mental and emotional state. One way of investigating an understanding of social cognition that contains multiple facets of information is to examine the ability to understand prosody in speech.

Prosody is a component of human speech that conveys important semantic, syntactic, and emotional meaning. Typically developing individuals utilize prosodic cues to disambiguate complex sentences, recognize emotions, and communicate effectively. On the other hand, individuals with ASC have been shown to have a difficult time correctly utilizing prosody

(Diehl, Bennetto, Watson, Gunlogson, & McDoanugh, 2008.) Evidence supports that prosodic receptive ability differs within individuals with autism as they are not able to pragmatically make use of the stress patterns, pauses, rhythms and contours of the language (Diehl et al., 2008; Kujala, Lepisto, Neinminen-von Wendt, Näätänen & Näätänen, 2005.) Prosody is not a unitary phenomenon, and investigations of prosodic deficits must address individual components.

Past behavioral studies have illustrated that individuals with ASC are unable to make use of prosodic pauses and intonation to disambiguate complex sentences and emotional content respectively (Diehl et al., 2008; Kujala et al., 2005.) Intonation is the prosodic component that most conveys emotional content in speech (Kujala et al., 2005.); the rising and falling patterns are associated with specific emotions. Individuals with ASC perform significantly worse than controls without autism in emotional recognition of speech (Kujala et al., 2005.)

It has been proposed that individuals with ASC have a difficult time integrating the literal meaning of the words/phrases in conjunction with prosodic cues (Diehl et al., 2008.) In other words, the language deficit within autism may be but one aspect of a domain-general deficit in integrative processing. However, an alternative explanation in terms of theory-of-mind (ToM) also could support the notion that individuals with ASC are unable to connect the emotional content of speech (Baron-Cohen, 1997.) Uncovering the mechanisms of how individuals with ASC are unable to associate these speech patterns to emotions will allow the behavioral neuroscience community to further understand the integrative processes in autism. The next step is to investigate individuals with ASC ability to identify emotions associated with prosodic intonation in full phrases/sentences.

In order to investigate both behavioral and neurophysiological processes within individuals with ASC we propose a study can be separated into two distinct phases. In the behavioral paradigm, the stimuli include full sentences with prosodic intonation conveying specific emotions such as happiness, sadness, questions, anger, etc. To untangle whether individuals with ASC have a difficult time with integration of words and prosodic context we plan to eliminate the words in the stimuli, the sentences will be passed through a low band pass filter. As a result only the prosodic intonational contours are decipherable. The task requires the individual to determine what emotion is being conveyed. If ASD participants are able to interpret the emotions from solely intonational contours, without the distraction of non-prosodic aspects of speech content, this would support the theory that the issue is one of integration rather than a domain-specific deficit of ToM. This study can be furthered by the addition of another condition to investigate the integration theory. The supplementary condition re-introduces the words in the sentence with the same task of recognizing the emotions conveyed. If in this case performance decreases, it is further support for the integration theory. However, if ASD individuals do not perform well in the initial task of intonation-based emotional recognition, ToM could be a more parsimonious explanation. Such a fundamental lack of recognition of intonation content would also be revealing, suggesting that there is something about prosody and the contours of speech that is not being well processed within individuals with ASC. In addition to investigating the behavioral outcomes of recognition of emotions through prosody we also want to examine possible neurophysiological differences.

The neurophysiological aspect of prosodic processing in autism will be investigated through use of an electroencephalogram (EEG.) In this component of the study, participants will listen to both intonation properties of the English language and tones that have no prosodic pattern. In order to keep the participants attending to the stimuli, the task will require that a button be pressed when the prosodic pattern of English is present. The EEG will reveal whether if there are any differences neurophysiologically between typically developing individuals and individuals with ASC when listening to prosodic patterns of English versus no prosodic pattern.

Prosody bears a significant amount of meaning that typically developing individuals are able to comprehend and ASD individuals struggle with. This proposed study specifically investigates the processing of solely prosodic intonation to examine whether the deficit within autism may be better explained by domain-specific impairment of ToM (social cognition) or a domain-general deficit of integrative processing. Autism spectrum condition is at the forefront of developmental disorders, and in order to treat it the mechanisms of behavior and neural processing must be fully understood. The proposed study is designed to understand both the behavioral and neurophysiological mechanisms of social cognition by looking at prosody processing in ASC.

Conclusions

Within the field of autism research there has yet to be concrete, established behavioral performances on certain tasks associated within individuals with ASC and unaffected siblings. There is conflicting evidence on whether individuals with ASC perform poorly on tasks tapping into social cognition (Dorris et al., 2004; Szatmari et al., 1993; Ozonoff et al., 1993; Shaked et al., 2006.) Within the visuospatial literature there also exists contradictory results concerning performances based on whether an individuals has ASC, is an unaffected sibling or typically developing individual (Szatmari et. al, 1993.) Within the social domain our study found that individuals with ASC performed significantly worse on the BFRT but performed as well as unaffected siblings and typically developing individuals. In the visuospatial domain we did not find any differences in Performance IQ of the WASI-II or the EFT. In addition we also found that unaffected sibling performed significantly better on the verbal portion of the WASI-II than both individuals with ASC and typically developing individuals. With our results, it is still unclear whether individuals with ASC have universal characteristics that are associated with certain tasks. It is difficult to draw any concrete conclusions our relationships between individuals with ASC and unaffected siblings from our data set for numerous reasons such as the size of our SIB population, the small sample size of all the groups for the EFT, the unbalanced groups, and non-uniform characteristics of the ASC group. It is evident that a more rigorous study is needed in order to draw clear conclusions concerning the behavior of individuals with ASC on tasks which test the domains of social cognition and visuospatial abilities.

BIBLIOGRAPHY

Baio, J. (2014). Prevalence of autism spectrum disorder among children aged 8 years autism and developmental disabilities monitoring network, 11 sites, United States, 2010. Surveillance Summaries, 63, 1-21.

Baron-Cohen S. (1997). Mindblindness. Cambridge: The MIT Press.

Baron-Cohen, S., Wheelwright, S., & Joliffe, T. (1997). Is there a 'Language of the eyes'? Evidence from normal adults, and adults with autism or Asperger syndrome. Visual Cognition, 4, 311–331.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y. & Plumb, I. (2001). The ``Reading the Mind in the Eyes" Test Revised Version: A Study with Normal Adults, and Adults with Asperger Syndrome or High-functioning Autism. Journal of Child Psychology and Psychiatry, 42, 241-251.

Benton, A. L., Sivan, A. B., Hamsher, K. De S., Varney, N. R., & Spreen, O. (1983). Contribution to Neuropsychological Assessment. New York: Oxford University Press.

Cohen, J. (1977). Quantitative methods in psychology: a power primer. Psychological Bulletin, 112, 155-159.

Constantino, J.N., & Todd, R.D. (2003). Autistic traits in the general population: A twin study. Archives of General Psychiatry, 60, 524–530.

Dawson, G., Estes, A., Munson, J., Schellenberg, G., Bernier, R. & Abbot, R. (2006.) Quantitative assessment of autism symptom-related traits in probands and parents: broader phenotype autism symptom scale. Journal of Autism and Developmental Disorders, 37, 523-536.

Diehl, J.J., Bennetto, L., Watson, D., Gunlogson, C., & McDoanugh, J. (2008). Resolving ambiguity: A psycholinguistic approach to understanding prosody in high-functioning autism. Brain & Language, 106, 144-152.

Dorris, L., Espie, C.A.E., Knott, F., & Salt, J. (2004). Mind reading difficulties in the siblings of people with Asperger's syndrome: evidence for genetic influence in the abnormal development of a specific cognitive domain. Journal of Psychology and Psychiatry and Allied Disciplines, 45, 412-418.

Gerdts, J., & Bernier, R. (2011). The broader phenotype of and its implications on the etiology and treatment of autism spectrum disorders. Autism Research and Treatment, 2011, 1-20.

Happe´, F., & Frith, U. (2006). The weak coherence account: Detail focused cognitive style in autism spectrum disorders. Journal of Autism and Developmental Disorders, 36, 5–25.

Kehrer, H,E. (1995). Savant capabilities of autistic persons. Acta Paedopsychaiatr, 2, 151-155.

Kirchner, J.C., Hatri, A., Heekeren, H.R., & Dziobek, I. (2010). Autistic symptomatology, face processing abilities, and eye fixation patterns. Journal of Autism Developmental Disorder, 41, 158-167.

Kujala, T., Lepisto, T., Neinminen-von Wendt, T., Näätänen, P., & Näätänen, R. (2005). Neurophysiological evidence for cortical discrimination impairment of prosody in Asperger syndrome. Neuroscience Letters. 383, 260-265.

Kuusikko, S., Haapsamo, H., Jansson-Verkasalo, E., Hurtig, T., Mattila, M., & Ebeling, H. (2010). Emotion recognition in children and adolescents with autism spectrum disorders. Journal of Autism Developmemtal Disorder, 39, 938–945.

Law Smith, M.J.; Montagne, B.; Perrett, D.I.; Gill, M; & Gallagher, L. (2010). Detecting subtle facial emotion recognition deficits in high-functioning Autism using dynamic stimuli of varying intensities. Neuropsychologia, 48, 2777-2781.

Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism Diagnostic Interview- Revised: a revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. Journal of Autism and Developmental Disorders, 24, 659-685.

Malisza, K.L., Clancy, C., Shiloff, D., Foreman, D., Holden, J., & Jones, C. (2010). Functional evaluation of hidden figures object analysis in children with autistic disorder. Journal of Autism Developmental Disorder. Retrieved from: file:///C:/Users/Darshana/Downloads/17649092.pdf

Minshew, N. J., Goldstein, G., & Siegel, D. J. (1997). Neuropsychologic functioning in autism: Profile of a complex information processing disorder. Journal of the International Neuropsychological Society, 3(4), 303–316.

Murphy, M., Bolton, P.F., Pickles, A., Fombonne, E., Piven, J., & Rutter, M. (2000). Personality traits of the relatives of autistic probands. Psychological Medicine, 30, 1411-1424.

Ozonoff, S., Rogers, S.J., Farnham, J.M., & Pennington, B.F. (1993). Can standard measures identify subclinical markers of autism? Journal of Autism and Developmental Disorders, 23, 429-441.

Scherf, S.K.; Behrmann, M.; Minshew, N; & Luna, B. (2008.) Atypical face and greeble recognition in autism. The Journal of Child Psychology and Psychiatry, 49, 838- 847.

Shaked, M., Gamliel, I., & Yirmiya, N. (2006). Theory of mind abilities in young siblings of children with autism. Autism, 10, 173-187.

Stone, W.L., McMahon, C.R., Yoder, P.J., & Walden, T.A., (2007). Early social-communicative and cognitive development oif younger siblings of children with autism spectrum disorders. Archives of Pediatrics and Adolescents Medicine, 161, 384- 390.

Szatmari, P., Jones, M.B., Tuff. L., Bartolucci, G., Fisman, S., & Mahoney, W. (1993). Lack of cognitive impairment in first degree relatives of children with pervasive developmental disorders. Journal of the American Academy of Child and Adolescent Psychiatry, 32, 1264-1273.

Tracy, J.L., Robins R.W., Schriber, R.A., & Solomon, M (2010). Is emotion recognition impaired in individuals with autism spectrum disorders? Journal of Autism Developmental Disorder, 102-109.

Toth, K., Dawson, G., Meltzoff, A.N., Greenson, J., & Fein, D. (2007). Early social, imitation, play, and language abilities of young non-autistic siblings of children with autism. Journal of Autism and Developmental Disorders, 37, 145-157.

Vellante, M., Baron-Cohen, S., Melis, M., Marrone, M., Petretto, D.R., Masala, C., & Preti, A. (2013). The “Reading the Mind and the Eyes” test: systematic review of psychometric properties and a validation study in Italy. Cognitive Neuropsychology, 4, 326-354.

Webb, S.J., Dawson, G., Bernier, R., & Panagiotides, H. (2006). ERP evidence of atypical face processing in young children with autism. Journal of Autism Developmental Disorder, 36,881–890

Weschler, D. (2011). WASI-II: Weschler abbreviated scale of intelligence – second edition. San Antonio, TX: Psychological Corporation.

Witkin, H.A., Oltman, P.K., Raskin, E.,& Karp, S.A. (1971). Manual for embedded figures test, children's embedded figures test, and group embedded figures test. Palo Alto, CA: Consulting Psychologist Press.

Wolf, J.M., Tanaka, J.W., Klaiman, C., Cockburn, J., Herlihy, L., Brown, C., McPartland, J., Kaiser, M.D., Philips, R., & Schultz, R.T. (2008.) Specific impairment of face-processing abilities in children with autism spectrum disorder using the Let's Face It! skills battery. Autism Research, 6, 329-340.

Yirmiya, N., Gamliel, I., Pilowsky, T., Baron-Cohen, S., Feldman, R., & Sigman, M. (2006). The development of siblings of children with autism at 4 and 14 months: Social engagement, communication and cognition. Journal of Child Psychology and Psychiatry, 47, 511–523.

Zwaigenbaum, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., & Szatmari, P. (2005). Behavioral manifestations of autism in the first year of life. International Journal of Developmental Neuroscience, 23, 143-152.